GEORGIA INSTITUTE OF TECHNOLOGY
EXPERIMENT STATION 225 North Avenue, Northwest · Atlanta, Georgia 30332

May 30, 1968

U. S. Army Missile Command
Research & Development Directorate
S&M Laboratory, Bldg. 5400, Rm. C-169
Redstone Arsenal, Alabama 35809

Attn: AMSMI-RSM, P. O. DAAH03-68-M-5577

Subject: Final Report, Project A-1078
Slip-Cast Fused Silica, Physical Property Test Specimens

Gentlemen:

The supplied fused silica physical property test specimens as per U. S. Army Missile Command drawing numbers 1429-A2, 1429-A4, and 1429-A7, were fabricated by slip-casting and machining to size with diamond tooling. Blanks were pressure slip-cast from Glasrock Products Batch No. 606B-Fused Silica Slip. In this operation a closed plaster of paris mold is filled with fused silica slip and allowed to cast under 20 psig air pressure until a solid casting is achieved. For 1-1/8-inch diameter blanks with 606-B slip this time period was about 30 minutes. After casting the bars were dried overnight at 125° F and then for 4 hours at 350° F. The bars were then fired at 2200° F for a period of 2 hours and 45 minutes. In this firing operation the bars are inserted into a furnace already operating at 2200° F. At the end of the firing period they are removed and allowed to cool in still air to room temperature.

Preparation of the gratis higher density thermal conductivity specimens slip-cast from G.E. 204 slip was the same as for the other specimens, except firing time at 2200° F was 20 hours.

The outer surfaces of the supplied specimens were finished by grinding with diamond impregnated metal tooling. Water only was used as a coolant. Holes were drilled in the specimens with diamond drills.

Slip 606-B was "characterized" by making certain measurements on the as received slip and on fired 3/4-inch diameter bars cast from this slip. The data taken on the slip and the cast bars are shown in Table I and Figures 1, 2, and 3. Data on the G.E. 204 slip are also included for comparative purposes. These data are self explanatory. The dynamic elastic modulus (Young's Modulus) versus sintering time at 2200° F is normally used as a control measure for determining optimum firing time. The sintering time at which maximum elastic modulus is reached is taken as the optimum firing time. The lower modulus of

B448 2a

rupture for the G.E. 204 material is believed to be due to surface conditions. A study of the effect of surface conditions on the critical strain of slip-cast fused silica is to be conducted on another project in the near future*.

A complete discussion on the characterization of fused silica slips has been prepared as a Special Report under U. S. Navy Contract N00017-67-C-0053**. This report contains a comprehensive discussion of the needs for characterization of fused silica slips and is a valuable reference for anyone contemplating extensive use of slip-cast fused silica.

Respectfully submitted,

J. N. Harris
Project Director

Approved:

J. D. Walton, Jr., Chief
High Temperature Materials Division

W. C. Whitley, Director
Engineering Experiment Station

JNH/jw

*USAF Contract F33615-67-C-1594.

**C. A. Murphy, Characterization of Commercial Fused Silica Slips, Contract N00017-67-C-0053, Georgia Institute of Technology, Engineering Experiment Station, Special Technical Report No. 2, April 1968.

TABLE I

CHARACTERIZATION DATA ON FUSED SILICA CASTING SLIPS

Property	Glasrock 606B	GE 204
pH	4.6	6.8
Apparent Viscosity[1] at		
60 rpm	89	81
30 rpm	91	80
12 rpm	109	95
6 rpm	125	120
Particle Size Distribution	Figure 1	Figure 1
Residual Crystalline Phases (Other than Cristobalite)	None	None
Residual Cristobalite (V/O)	0.08	None
Spectrographic Analysis Parts per million of -		
Mg	2-5 ppm	10-40 ppm
Fe	50-200 ppm	5-20 ppm
Al	20-100 ppm	Trace 2 ppm
Ti	50-100 ppm	-
Ca	-	2-20 ppm
Zn	5-20 ppm	-
Cr	5-20 ppm	-
Cristobalite vs Time @ 2200° F	Figure 2	Figure 2
Young's Modulus vs Time @ 2200° F	Figure 3	Figure 3
Modulus of Rupture[2] sintered 15 hrs @ 2200° F	5405 ± 175 psi	4245 ± 445 psi
Elastic Modulus[2] sintered 15 hrs @ 2200° F	$4.54 \pm 0.09 \times 10^6$ psi	$7.00 \pm 0.45 \times 10^6$ psi

[1] Measured with Brookfield Synchro-Lectric Model LVF Using No. 2 Spindle.

[2] Glasrock 606B fired for 2 hrs - 45 min.

(Continued)

TABLE I (Continued)

CHARACTERIZATION DATA ON FUSED SILICA CASTING SLIPS

Property	Glasrock 606B	GE 204
Compressive Strength[2] sintered 15 hrs @ 2200° F	27,600 ± 5000 psi	N.A.
Other Properties[2] sintered 15 hrs @ 2200° F		
a. Porosity (%)	13.61 ± 0.14	10.88 ± 1.52
b. Bulk Density (gm/cc)	1.942 ± 0.004	2.006 ± 0.038
c. Theoretical Density (gm/cc)	2.26	2.252 ± 0.054

[2]Glasrock 606B fired for 2 hrs - 45 min.

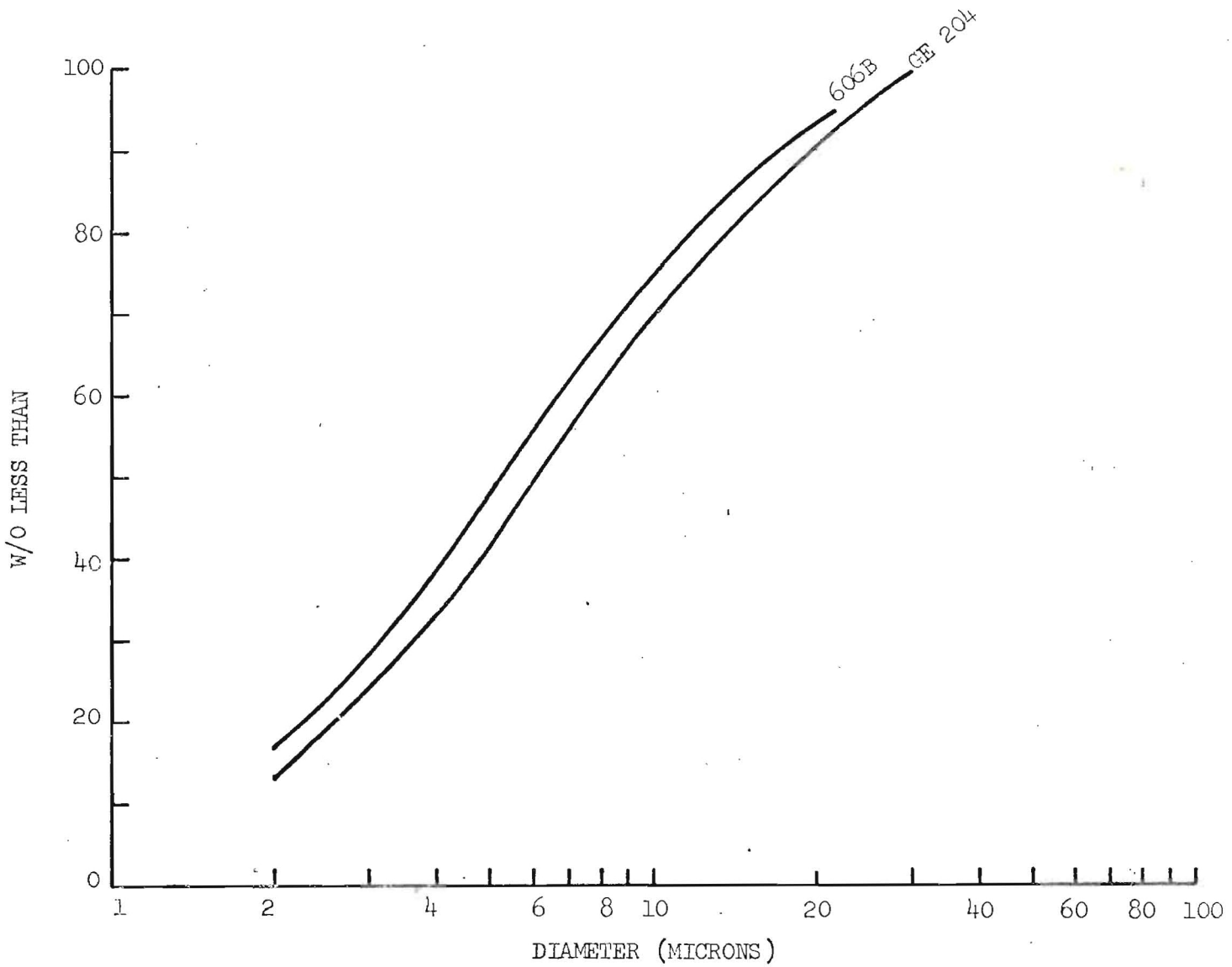

Figure 1. Particle Size Distribution - Glasrock 606B and GE 204 Fused Silica Slips.

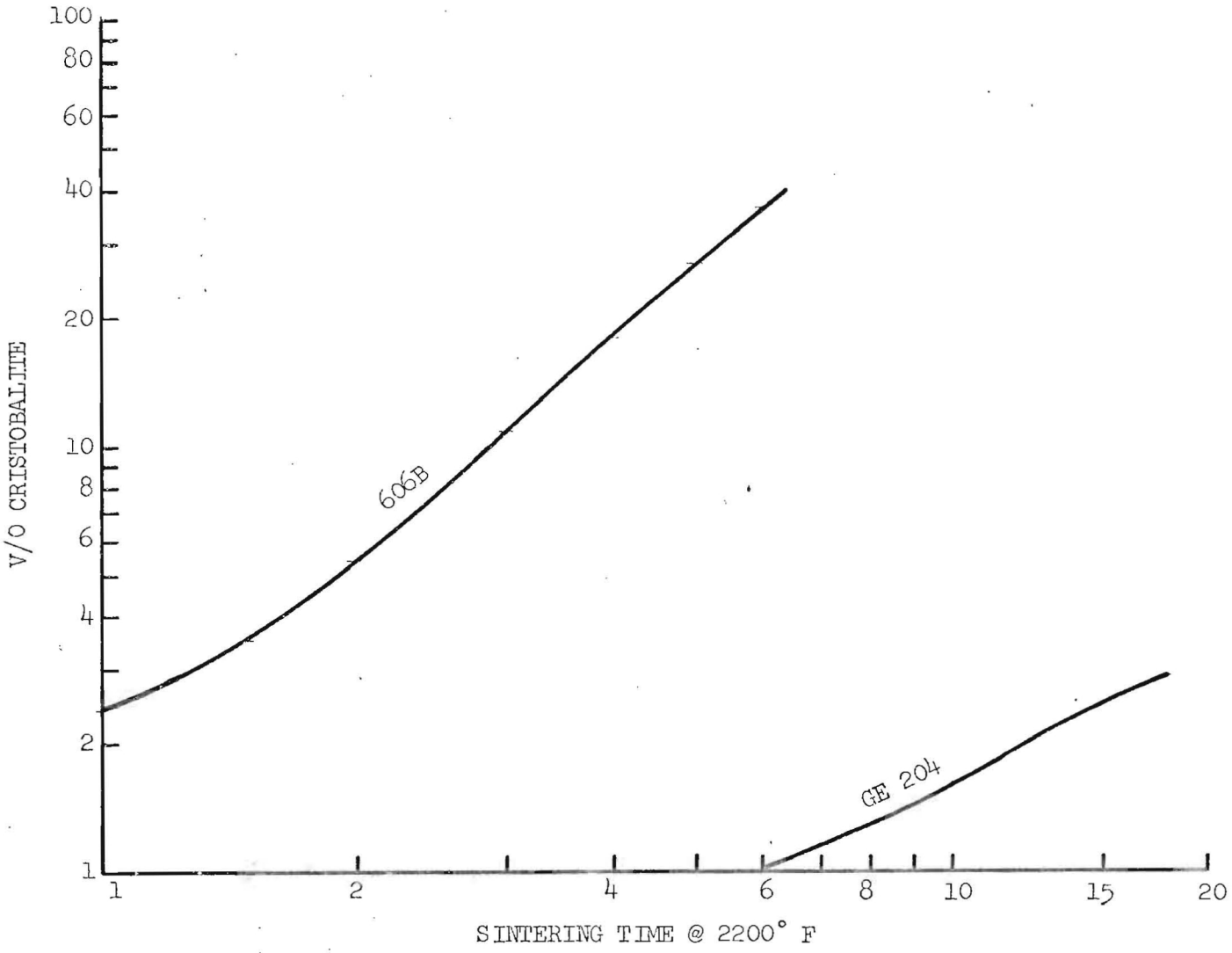

Figure 2. Volume Per Cent Cristobalite vs Sintering Time @ 2200° F For Glasrock 606B and GE 204 Fused Silica Slips.

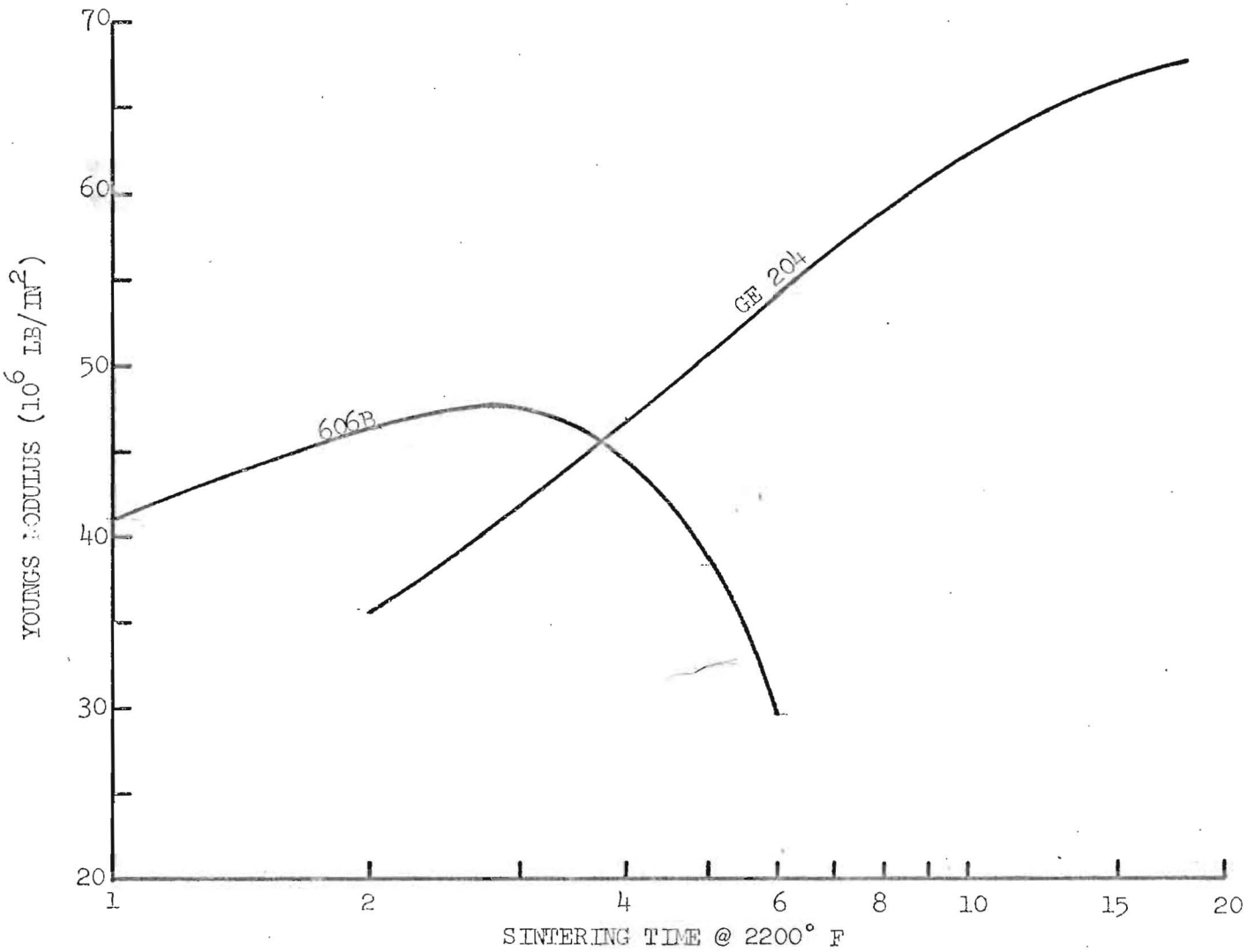

Figure 3. Youngs Modulus vs Sintering Time @ 2200° F for Glasrock 606B and GE 204 Fused Silica Slips.

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June 25, 1968

U. S. Army Missile Command
Research & Development Directorate
S&M Laboratory, Building 5400, RMC-169
Redstone Arsenal, Alabama 35809

Attention: AMSMI-RSM, P. O. DAAH03-68-M-5577

Subject: Errata, Final Report, Project A-1078, Slip-Cast Fused Silica Physical Property Test Specimens, 30 May 1968

Gentlemen:

A review of the Figures accompanying the subject Final Report reveals that they were reproduced with errors such as abbreviations and incomplete titles in the legends. Also in Figure 3 the decimal points for the numbers on the ordinate were left out.

A complete set of corrected figures have been prepared to accompany the subject report. Please replace the existing figures with the enclosed new figures.

Respectfully submitted,

J. N. Harris
Project Director

Approved:

N. E. Poulos, Associate Chief
High Temperature Materials Division

Wyatt C. Whitley, Director
Engineering Experiment Station

JNH/jw
Enclosures (3)

ERRATA

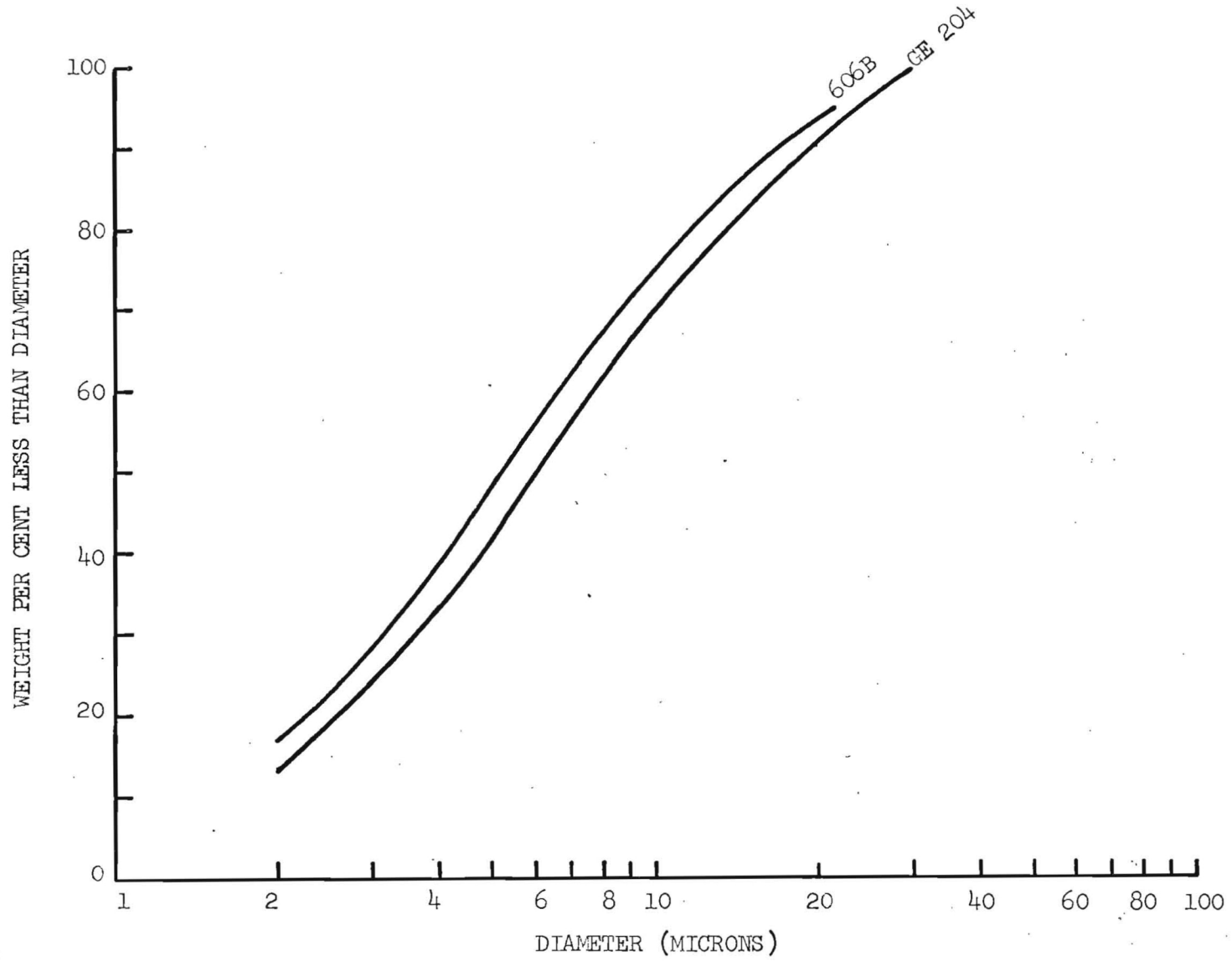

Figure 1. Particle Size Distribution - Glasrock 606B and GE 204 Fused Silica Slips.

ERRATA

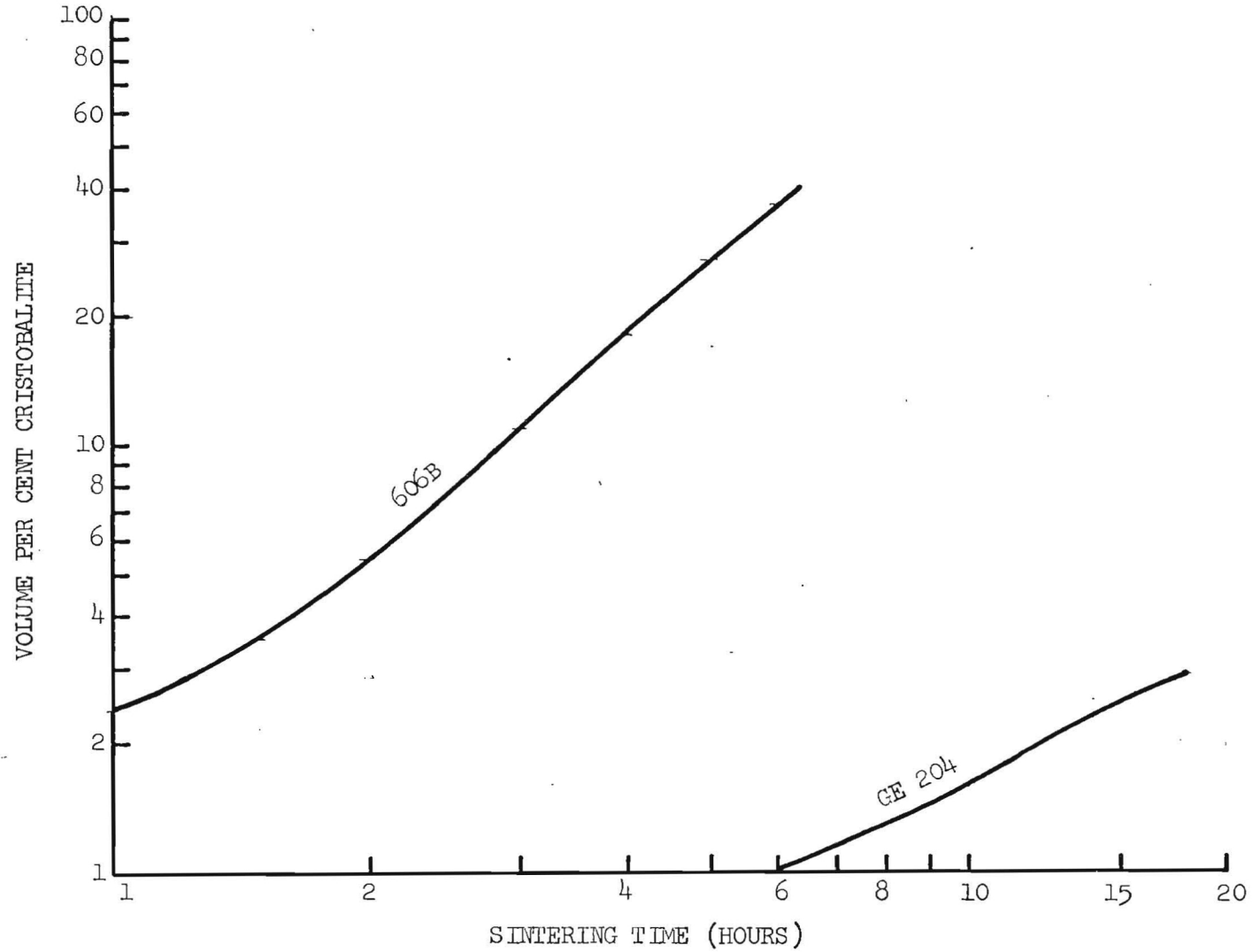

Figure 2. Volume Per Cent Cristobalite vs Sintering Time @ 2200° F For Glasrock 606B and GE 204 Fused Silica Slips.

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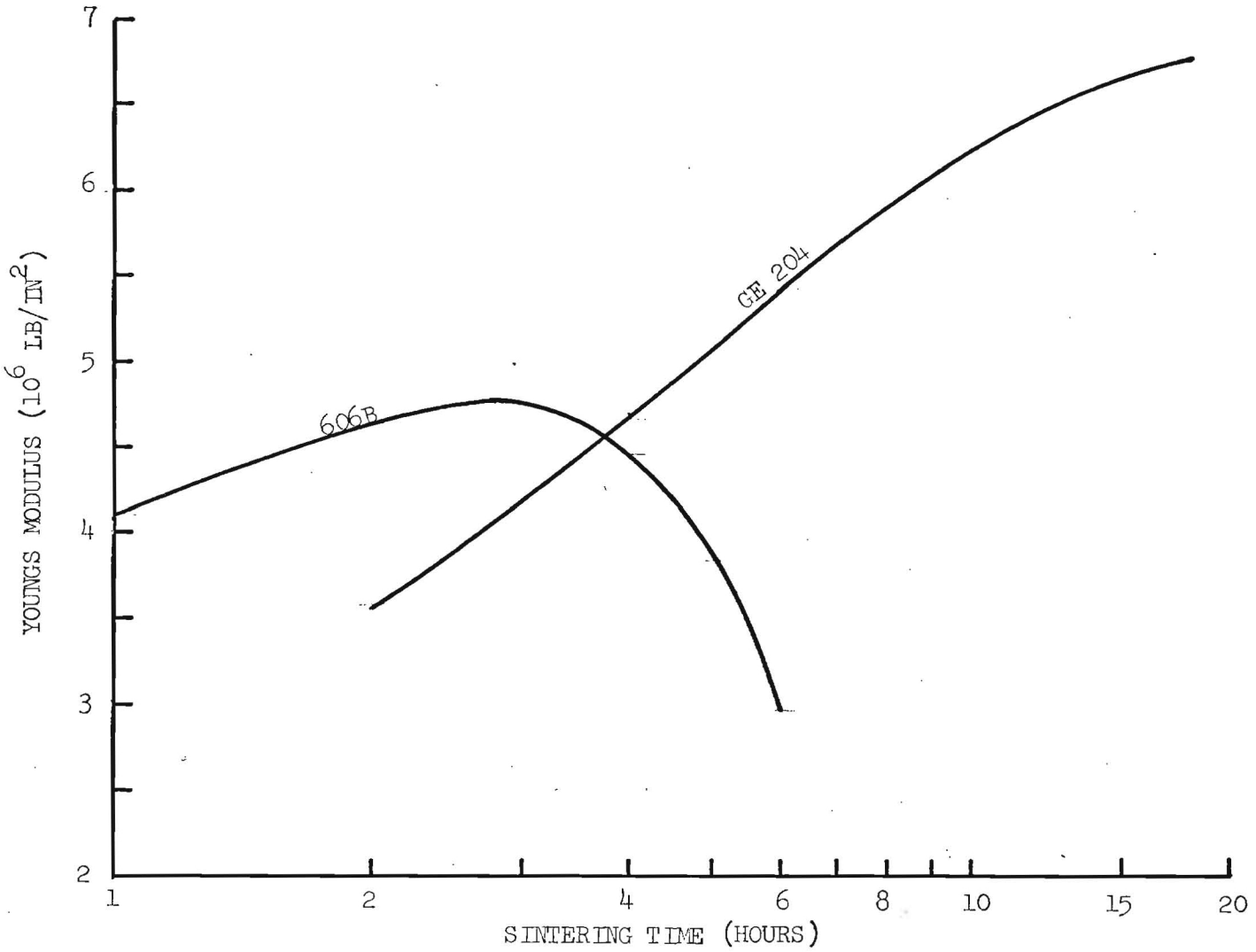

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